## REMARKS

The Office Action of December 10, 2008 for the above referenced matter has been received and carefully considered.

Claims 19, 101-113, 115-131, 133-135,144-152, 154 and 155 currently stand rejected under 35 U.S.C. § 112, second paragraph. Claims 1-4, 8-24, 26-31, 40-59, 63-83, 92-113, 115-135 and 144-152 currently stand rejected under 35 U.S.C. § 103(a). Claims 19, 77-78, 101, 151 and 155 have been amended. No new matter has been added.

Based on the manifest differences between the cited references and the claimed invention, the Applicant believes that the following remarks will illustrate for the Examiner that the rejections in the December 10, 2008 Office Action should be reconsidered and withdrawn.

A. Claim Rejections Under 35 U.S.C. § 112, Paragraph 2

Claims 19, 101-113, 115-131, 133-135,144-152, 154 and 155 currently stand rejected under 35 U.S.C. § 112, second paragraph for including, or dependency on a claim that includes, the phrase "nosecone". According to the Examiner, the phrase "nosecone" in Claims 19, 77-78, 101, 151 and 155 "is indefinite because the specification does not clearly redefine the term." (Office Action of December 10, 2008, page 2). Claim 19, which is indicative of claims 77-78, 101, 151 and 155 has been amended, and now recites "cone-shaped vapor orifice." Claims 102-113, 115-131, 133-135 144-150, 153 depend from claims that were amended, and thus, do not include any reference or dependency on the phrase objected to by the Examiner. Thus, Applicant respectfully

requests the Examiner's withdrawal of the § 112 rejection of Claims 19, 101-113, 115-131, 133-135,144-152, 154 and 155.

B. Claim Rejections Under 35 U.S.C. § 103(a)

The Examiner has rejected claims 1-3, 8-20, 29-31, 40-53, 55, 66-82, 92-107, 109, 115-116, 118-135 and 144-155, under 35 U.S.C. § 103(a) as being unpatentable over U.S.C. 103(a) as being unpatentable over Saito (JP 62-237721) taken in view of Sarraf (5,558,720), Zega (4,112,137), DeLange (2,508,500) and Dale (3,634,647), and in further view of Bennet (2,568,578) and Mercer (5,407,000), and optionally in further view of Colombo (5,827,371)". Reconsideration of the Examiner's § 103(a) rejection in light of the following comments.

Initially, the Applicant asserts that the distinctions between the present principles as claimed and the prior art include the geometry and configuration of key elements, the physical method for liquid metal transport, the driving forces for liquid metal transport and metal containment in the reservoir and the ability to evaporate very high melting point metals. None of these features are disclosed or rendered obvious by any of the cited prior art references, whether taken singly, or in any combination.

With regard to Claim 1 specifically, Saito fails to teach, disclose or render obvious the Claim 1 features of "an evaporator...", "a hollow reservoir..." and "a hollow transport tube ...said hollow transport tube connecting said evaporator and said reservoir cylinder."

Saito teaches the use of an "external" liquid Ga reservoir located outside of a vacuum system which is used to fill a high temperature thermal evaporator located within

a vacuum system. A conductive probe is used to sense the level of the Ga in the evaporator to control an "on-off" vacuum-seal valve outside of the vacuum system to feed liquid Ga into the evaporator. Saito uses gravity to induce an internal pressure in the liquid Ga reservoir that serves as the driving force for flow of liquid Ga through the vacuum-seal valve. Saito discloses, in Figure 1, a transport tube to enable flow of liquid Ga that is physically attached to the base of a cone-shaped evaporation crucible. As is well-known to those experienced in the art of Molecular Beam Epitaxy (MBE), the preferred materials used in the construction of the cone-shaped MBE crucible are either pyrolytic boron nitride (PBN), pyrolytic graphite (PG), or purified machined graphite. These preferred materials are conventionally used since they are chemically pure (impurity levels of a few parts-per-million) and also do not wet or chemically react with molten Ga and many other metals at normal evaporation temperatures in the range of 800-1300C. As shown in Figure 1 in Saito, the transport tube passes through a vacuum-sealed flange which in turn is connected to a control valve, which further is connected to the external liquid Ga reservoir tank. Therefore, if the transport tube connected to the base of the cone-shaped crucible is made from either PBN, PG, or purified machined graphite, then the transport tube must form a vacuum seal with the mating feedthrough flange (conventionally made from stainless steel) attached to the MBE system. However, it is not technically possible to weld or braze a connection to the stainless steel flange using either a PBN, PG, or purified machined graphite transport tube since these materials are not wet by any known welding or brazing metals. An alternative method would be to use a Ga transport tube made from metal that could be welded to the stainless steel flange to make a vacuum seal. This alternate method would then require that a leak-

tight seal be made between the metal transport tube and the base of the cone-shaped crucible within the vacuum system. However, it is well known that Ga and other liquid metals will chemically react with and corrode most common metals, especially at high temperatures, including Mo, Ta, W, Ti, Fe, Ni, Cr, etc. leading to the formation of intermetallic compounds. Thus skilled practitioners of the art will recognize that any transport tube made from metals will be corroded by Ga and/or other liquid metals causing eventual failure of a leak-tight seal near the base of the cone-shaped crucible that is operated at high temperatures. Thus, the teachings of Saito fail to take high temperature liquid metals into account and thus, cannot render obvious the evaporator connected to the reservoir via a connecting tube as recited in Claim 1.

Saito further teaches the use of a gravity feed transport of liquid metal regulated by a valve control that is well known to those skilled in the art. Saito requires the liquid metal reservoir to be positioned higher than the level of the metal in the evaporator. Such a requirement is a major limitation in the Saito invention due to difficulties in practical implementation of this geometry in many evaporation systems. In contrast, the present principles as claimed, recite "a hollow reservoir cylinder having a cylindrical piston." The claimed piston element permits the close control of the flow of liquid metal into the evaporator, a feature that Saito fails to teach or render obvious. By using precision control of the piston motion, the elements of Claim 1 permit accurate maintenance of the metal level height in the evaporator to achieve a constant metal evaporation rate at a fixed evaporator temperature. In contrast, Saito requires constant monitoring and adjustment of the vacuum-seal valve through constant opening and closing of the valve in order

maintain metal height level control. Such constant activity at the valve can cause premature valve failure, a design flaw overcome by the invention as recited in Claim 1.

Sarraf uses capillary action to transport the metal to the evaporation surface via a capillary wick formed in the capillary tube. This capillary tube is coated with sintered tungsten powder. Such use of a small diameter capillary tube actually "wets" or chemically attracts the liquid metal in order to draw the metal up from the reservoir, through the capillary tube and into the evaporator.

In contrast, the elements recited in Claim 1, most notably the "hollow reservoir cylinder having a cylindrical piston" permit for a controlled flow of liquid metal though the hollow tube connecting the reservoir with the evaporator. The active pressure in the reservoir negates any need for chemical wetting of the connecting tube, which causes a fixed flow rate of the molten metal. Varying the flow rate in a constant environment is impossible under the teachings of Sarraf, as the geometry and composition of the connecting tube determines how the molten metal wets the tube to create the capillary action. Thus, the teachings of Sarraf teach away from such a feature, as Sarraf discloses the use of capillary action instead of pressurized, controlled liquid metal flow.

Another limitation introduced by the teachings Sarraf is that the actual surface area for evaporation is determined by the open porosity of the porous tungsten coating on the evaporator. As is known in the art, the metal mass evaporation rate is equal to the integral of the product of the open surface area and the local, temperature-dependent metal effusion rate (gm/cm$^2$-sec). The actual open surface area of the evaporator disclosed by Sarraf is dependent upon the porous tungsten production process to form the evaporator coating. Thus, Sarraf will suffer from differences in metal evaporation rates

from nominally identical metal evaporators operating at the same fixed evaporator temperature due to variations in the porous tungsten forming process and from the negative temperature gradient from top to bottom of the evaporator.

In contrast, the claimed evaporator connected to a piston controlled reservoir creates a well-defined, constant surface area cross-section that is located in a thermally-shielded, constant temperature evaporation zone. The evaporated metal is dispersed onto the target substrate using the "cone-shaped vapor orifice". Therefore, invention as claimed will have essentially identical metal evaporation rates from nominally identical evaporators when operated at the same temperature. Therefore, claim 1 overcomes deficiencies in the teachings of Sarraf, and thus, cannot be anticipated or rendered obvious by Sarraf.

De Lange teaches the use of heating elements around the feed tube only, and fails to teach a heating element on the evaporator and the use of three separate temperature zones (high, intermediate and low temperature zones). In fact, De Lange teaches away from heating the evaporator metal directly by suggesting the use of heat conduction of the liquid metal up the evaporation tube. (De Lange, col. 3, 42-57). Thus, De Lange is limited to metals with low melting point and evaporation temperatures.

Dale also fails to teach, suggest or render obvious the Claim 1 elements of "an evaporator...", "a hollow reservoir..." and "a hollow transport tube ...said hollow transport tube connecting said evaporator and said reservoir cylinder." Dale teaches the use of a capillary tube to feed a mixture of liquid metals to a high temperature evaporator. In Dale, the metal alloy evaporation rate is determined by the mass flow rate through the capillary tube. Conversely, the invention as claimed in Claim 1 recited an evaporator

where the metal evaporation rate is determined by the vapor pressure over the metal surface which is directly controlled by the evaporator temperature. In Dale, the evaporator temperature must be sufficiently high to completely evaporate the continuous metal alloy flow impinging onto the evaporator surface without accumulation, and therefore in Dale, the evaporator temperature does not directly control the deposition rate. The limitations in Dale in the use of a capillary tube with potential problems of metal wetting and mass flow restricted flow are similar to those in Sarraf. The invention as recited in Claim 1 overcomes these limitations. Therefore, Dale cannot anticipate or render obvious all of the elements of Claim 1.

Bennett teaches the use of coaxial heated metal tubes to transfer liquid metal between containers at atmospheric pressures. Bennett uses an external tube in thermal contact but electrically isolated from the inner tube used to transport liquid metal. Electrical current is passed directly through the outer metal tube wall to resistively heat it, and by thermal contact, the inner tube above the melting point temperature of the metal. The teachings of Bennett cannot anticipate or render obvious the three zone temperature control recited in Claim 1, as the teachings of Bennett merely teach a method for heating, and not keeping the reservoir, transport tube and evaporator at different temperatures.

Furthermore, none of the other references even teach three separate temperature zones, each temperature zone having a different temperature. Each of the Saito, Sarraf, Zega, and De Lange references taken singly and in combination with the Dale, Bennett and Mercer references do not teach a high, intermediate and low temperature zone for the said evaporator, said transport tube and said reservoir, respectively.

Zega teaches the use of reactive sputtering to deposit metal oxides on a target. Reactive sputtering involves the use of high energy ions within low pressure (~$10^{-3}$ Torr) plasmas to kinetically sputter metal atoms from a target onto a substrate by ion bombardment and chemical reaction of the sputtered metals on the deposition surface with $O^+$ ions and O neutral atoms. Thus, Zega cannot teach "an evaporator configured to evaporate liquid metal" or a "hollow transport tube connecting said evaporator and said reservoir cylinder" as recited in Claim 1 because Zega does not teach thermal evaporation of metal. In contrast, the thermal metal evaporation recited in Claim 1 relies on direct temperature control in the metal evaporator to regulate the metal deposition rate.

Furthermore, since the teachings of Zega rely on bombardment of a metal source with ion to strip metal molecules from the metal source, instead of evaporative metal deposition as recited in Claim 1. Therefore, Zega teaches away from the three zone temperature control of Claim 1.

The Examiner also cites Colombo as teaching the use of a pyrolytic boron nitride (PBN) crucible. However the teachings of Colombo are merely directed to providing a larger volume of loaded metal in the PBN crucible and a slower decrease in the metal evaporation rate at a fixed evaporator temperature as metal is depleted through evaporation compared to prior art cone-shaped PBN evaporation crucibles. The drawbacks of a system such as that taught by Colombo include the metal evaporation rate continually decreasing with time due to metal depletion from evaporation since the metal surface recedes and is at a further distance from the orifice. Furthermore, changes in cross-sectional metal surface area as the metal depletes leads to abrupt changes in the slope of the evaporation rate decrease. In contrast, the apparatus recited in Claim 1

provides for a constant metal evaporation rate (experimentally measured stability of 0.1%) by continuously measuring and feedback controlling the height of the liquid metal in the evaporator using a piston and cylinder liquid metal pump in combination with a level sensor control. The precise control of the evaporation rate of the liquid metal provides a system permitting mass production of semiconducting layers with accurately controllable precision in thickness and composition control which results in lower overall manufacturing costs.

Thus, Colombo cannot render obvious at least the Claim 1 feature of an "evaporator configured to evaporate liquid metal", "a hollow reservoir cylinder having a cylindrical piston" and "a hollow transport connecting said evaporator and said reservoir cylinder."

Furthermore, Colombo does not disclose, or render obvious in any way the three zone temperature control disclosed in Claim 1.

Thus, none of the cited prior art, whether taken singly or in any combination, disclose, teach or render obvious the Claim 1 elements of "evaporator configured to evaporate liquid metal", "a hollow reservoir cylinder having a cylindrical piston" and "a hollow transport connecting said evaporator and said reservoir cylinder." Furthermore, none of the cited prior art taken singly or in combination, teaches the three zone temperature control recited in Claim 1. Therefore, Claim 1 is patentable over the cited prior art references for at least the reasons discussed above.

Independent Claim 49 recites a separate heating zone system analogous to that recited in Claim 1, and, is therefore, patentable over the cited prior art references for at the same reasons discussed above for Claim 1. Independent Claim 101 recites an

evaporator, reservoir with piston and transport tube analogous to elements recited in Claim 1, and is therefore, patentable over the cited prior art references for at least the same reasons as Claim 1.

Claims 2-3, 8-19, 29-31, 40-48 and 154-155 depend from independent claim 1, claims 50-53, 55, 66-78, 81-82 and 92-100 depend from independent claim 49, and claims 102-107, 109, 115-116, 118-131, 133-135 and 144-153 depend from independent claim 101. By virtue of their dependencies, claims 2-3, 8-19, 29-31, 40-48, 50-53, 55, 66-78, 92-100, 102-107, 109, 115-116, 118-135 and 144-152 have all the limitations of the claims from which they depend. Thus, claims 2-3, 8-20, 29-31, 40-48, 50-53, 55, 66-82, 92-100, 102-107, 109, 115-116, 118-135 and 144-152 are patentable over the cited prior art for at least the same reasons as independent claims 1, 49 and 101. Therefore, the Applicant respectfully requests the Examiner's withdrawal of the 35 U.S.C. § 103(a) rejection of claims 1-3, 8-20, 29-31, 40-53, 55, 66-82, 92-107, 109, 115-116, 118-135 and 144-152.

The Examiner has rejected claims 4, 29-31, 51-54, 81-83, 99, 105-108 and 133-135, under 35 U.S.C. § 103(a) as being unpatentable over Saito, taken in view of Sarraf, Zega, De Lange, Dale, Bennett, and Mercer and optionally in view of Colombo for the reasons stated above, and taken in further view of Chow U.S. Patent No. 5,031,229 ("Chow"). Applicant respectfully disagrees and requests reconsideration of the Examiner's § 103(a) rejection in light of the following comments.

The Examiner cited Chow as teaching the use of pyrolytic graphite to form the heater elements on the outer surface of the evaporator. However, the claimed invention does not claim pyrolytic graphite to form the heater elements. Instead the present

invention claims pyrolytic graphite to coat the evaporator, transport tube and reservoir themselves. Referring specifically to claim 4, "wherein at least one of said evaporator, said transport tube and said piston are coated with a layer of Pyrolytic Graphite." Graphite is superior for the evaporator, transport tube and reservoir because it has an efficient black-body radiation absorption configured to reduce the power required by the heating element to achieve a selected operating temperature. None of the other cited prior art references teach, suggest or render obvious this feature. The Chow reference taken singly or in combination with the other cited prior art references does not teach, suggest or render obvious the specific use of pyrolytic graphite in the claimed invention.

Claims 4 and 29-31 depend from independent claim 1, claims 51-54, 81-83 and 99 depend from independent claim 49, and claims 105-108 and 133-135 depend from independent claim 101. By virtue of their dependencies, claims 4, 29-31, 51-54, 81-83, 99, 105-108 and 133-135 have all the limitations of the claims from which they depend. Thus, claims 4, 29-31, 51-54, 81-83, 99, 105-108 and 133-135 are patentable over the cited prior art for at least the same reasons as independent claims 1, 49 and 101. Therefore, the Applicant respectfully requests the Examiner's withdrawal of the 35 U.S.C. § 103(a) rejection of claims 4, 29-31, 51-54, 81-83, 99, 105-108 and 133-135.

The Examiner has rejected Claims 21-24, 26-27, 56-69 and 110-113 as being unpatentable over Saito taken in view of Sarraf, Zega, De Lange, Dale, Bennet and Mercer, and optionally taken in view of Colombo and in further view of United States Patent No. 2,195,071 to Bahney ("Bahney").

Applicant respectfully disagrees and requests reconsideration of the Examiner's § 103(a) rejection in light of the following comments.

Claims 21-24, 26 and 27 depend from independent claim 1, claims 56-59 depend from independent claim 49 and claims 110-113 depend from independent claim 101. As discussed above for claims 1, 49 and 101, Sarraf taken in view of Zega, De Lange and Dale, and taken in further view of Bennett and Mercer, fail to teach, suggest or render obvious three separate temperature zones with three separate heating elements for each of the three separate temperature zones, a "cone-shaped vapor orifice" with a probe disposed therein. By virtue of their dependencies, claims 21-24, 26, 27, 56-59 and 110-113 feature all of the limitations of independent claims 1, 49 and 101, respectively. Chow further fails to teach, suggest or render obvious any of the limitations discussed above for independent claims 1, 49 and 101. Thus, claims 21-24, 26, 27, 56-59 and 110-113 are patentable over the cited prior art references. Therefore, the Applicant respectfully requests the Examiner's withdrawal of the 35 U.S.C. § 103(a) rejection of claims 21-24, 26, 27, 56-59 and 110-113.

The Examiner rejected claims 28, 63-65, 116 and 117, under 35 U.S.C. § 103(a) as being unpatentable over Saito, taken in view of Sarraf, Zega, De Lange, Dale, Bennett, Mercer and optionally in view of Colombo and Bahney for the reasons stated above, and taken in further view of Komiyama JP Patent No. 53-019135 ("Komiyama"). Applicant respectfully disagrees and requests reconsideration of the Examiner's § 103(a) rejection in light of the following comments.

Claim 28 depends from independent claim 1, claims 63-65 depend from independent claim 49 and claims 116 and 117 depend from independent claim 101. As discussed above for claims 1, 49 and 101, Sarraf taken in view of Zega, De Lange and Dale, and taken in further view of Bennett and Mercer, fail to teach, suggest or render

obvious three separate temperature zones with three separate heating elements for the three separate temperature zones, a "cone-shaped vapor orifice" with a probe disposed at the "cone-shaped vapor orifice", or heating elements that heat by infrared radiation. By virtue of their dependencies, claims 28, 63-65, 116 and 117 feature all of the limitations of independent claims 1, 49 and 101, respectively. Chow further fails to teach, suggest or render obvious any of the limitations discussed above for independent claims 1, 49 and 101. Bahney also further fails to teach, suggest or render obvious any of the limitations discussed above for independent claims 1, 49 and 101. Thus, claims 28, 63-65, 116 and 117 are patentable over Sarraf taken in view of Zega, De Lange and Dale, taken in further view of Bennett and Mercer, and taken in further view of Komiyama. Therefore, the Applicant respectfully requests the Examiner's withdrawal of the 35 U.S.C. § 103(a) rejection of Claims 28, 63-65, 116 and 117.

## CONCLUSION

In view of the foregoing, the Applicant submits that the specification, drawings and pending claims represent a patentable contribution to the art and are in condition for allowance. Early and favorable action is accordingly solicited.

Respectfully submitted,

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